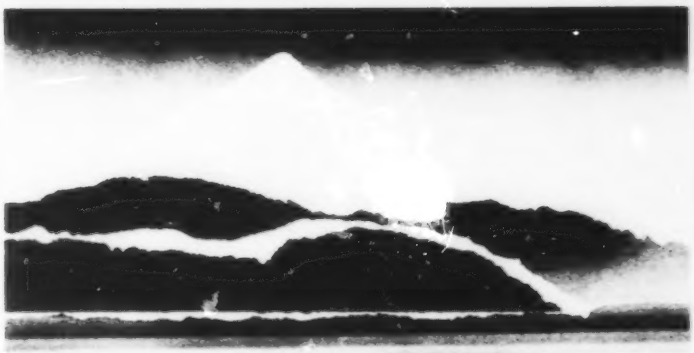
LOWER COLUMBIA RIVER
HUGH KEENLEYSIDE DAM TO BIRCHBANK
WATER QUALITY ASSESSMENT AND OBJECTIVES



BC Environment
Water Management Division

MINISTRY OF ENVIRONMENT, LANDS AND PARKS
PROVINCE OF BRITISH COLUMBIA

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J. O'Riordan
Assistant Deputy Minister

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INTRODUCTION

This is the first of two reports assessing water quality and setting water quality objectives for the lower Columbia River from the Hugh Keenleyside Dam to the U.S. border. In this report the 28 km reach from the dam to Birchbank is considered.

The status of existing and future water quality is examined with respect to the existing and future water uses. Provisional water quality objectives are set to protect designated water uses. A monitoring program to check the attainment of these objectives is recommended. The goal of this report is to guide the water quality management of this reach of the Columbia River. A detailed technical appendix was prepared and forms the basis for the conclusions presented in this summary.

HYDROLOGY

This reach begins approximately 700 km downstream from the headwater source of the Columbia River and ends approximately 60 km upstream from the B.C.-Washington border. Streamflow regulation of this reach began in 1968 with the construction of the Hugh Keenleyside Dam. Since regulation, winter flows have increased as water is released, and spring/summer flows have decreased as the floods are stored. The period of low flow varies between early March and late June. As specified by the Columbia River Treaty, the average weekly outflow from the Keenleyside Dam is to be greater than 142 m^3/s, except if agreed otherwise by the Treaty signatories. On average, flows of approximately 142 m^3/s occur approximately 3.5 percent of the time.

The mean annual flow of the Columbia River at the Keenleyside Dam increases from 1110 m^3/s at the Keenleyside Dam to 2020 m^3/s at Birchbank. The Kootenay River is the largest tributary within this reach contributing 43% of the mean annual flow at Birchbank. The Kootenay River thus provides significant dilution for anthropogenic discharges within this reach.

WATER USES

Present licensed water withdrawals represent 1.8 % of the minimum outflow from the Keenleyside Dam. The largest water use (69.2%) is for industrial purposes at the Westar Timber Ltd. sawmill and the Celgar pulp mill. Irrigation of gardens and hay crops accounts for 30.5 %. Only 0.01 % of the withdrawal is for domestic consumption. The City of Castlegar takes its water supply directly from the Arrow Reservoir via pipeline as do Celgar and Westar.

A total of 22 fish species are known to inhabit the Columbia River between the Keenleyside Dam and the U.S. border. Of these, there are six important sport fish species: rainbow trout, yellow walleye, mountain whitefish, kokanee, Dolly Varden char, and burbot. Their presence provides for a popular sport fishery which is the dominant water-based recreational activity in this reach. Other recreational attributes of the river are boating, swimming, and aesthetics (tourism,viewing). Water quality has been identified as the principal factor detracting from the enjoyment of river recreation in this reach.

WASTE DISCHARGES

The most important waste discharges affecting water quality in this reach of the Columbia River are the industrial effluent from the Celgar pulp mill (PE 1272) and the treated sewage effluent from the City of Castlegar (PE 80, PE 4008). There are several smaller discharges of treated sewage which are not considered to be problems, including that from the sawmill and pulp mill (PE 1273), from a neighborhood pub (PE 7622), and from Selkirk College (PE 141).

Non-point Sources

Diffuse-source contamination from land activities does not appear to have any significant effect on river water quality. Agriculture is largely part-time and limited to small-scale livestock production and irrigated hay crops. There are some unpermitted domestic effluent discharges with the potential for localized fecal contamination, but not discerned by available river water quality monitoring data. There are two landfills operated by the sawmill and pulp mill located approximately 150 m from the river's edge; however,

leachate is routed to an exfiltration pond and effects in the river have not been measured. Water-based log storage and handling at the sawmill and pulp mill have altered the benthos with sunken logs, branches, and bark debris, and has the potential (though undocumented) to degrade the quality of the overlying water column.

Celgar Pulp Mill

The Celgar pulp mill is the oldest interior kraft pulp mill and, since start-up in 1961, it has discharged untreated effluent to the Columbia River via a submerged diffuser located 3.3 km downstream from the Keenleyside Dam. Although some progress in effluent improvement has been made in recent years, by present industry standards the pulp mill is functionally obsolescent. Beginning in 1991, Celgar is rebuilding and expanding the mill, increasing production from 560 to 1200 ADt/d. Approval for the expansion was given after review by a panel convened jointly by the Federal and Provincial Governments. Details of the mill process changes are provided in the Technical Appendix.

Important future changes relative to receiving water quality include: installation of secondary treatment; a reduction in mean effluent flow from 116 000 m^3/d to 93 000 m^3/d (summer) and 76 900 m^3/d (winter); a 40 % reduction in chlorine usage; and reduction in chlorinated dioxins and furans to levels below current detection limits. Reductions in the effluent levels of BOD, suspended solids, colour, and toxic organics (Adsorbable Organic Halogens (AOX), resin acids, phenolics) are also expected after 1994 with the completion of mill modernization. Effluent phosphorus levels are expected to remain high (102 kg/d compared to present loading of 112 kg/d), while nitrogen levels are expected to increase from the present level of 350 kg/d to 511 kg/d.

The effluent from the Celgar pulp mill in its pre-modernized condition has consistently exceeded permit target levels for BOD, suspended solids, pH, and toxicity. Rainbow trout bioassay data indicate that the 96-h LC50 of the effluent ranged from 2.6 to 30% and averaged 13%. Extrapolation from the bioassay data indicates that receiving water concentrations at low flow were 7 to 70 times higher than the safe levels recommended for persistent and cumulative toxicants, after complete mixing. With the exception of levopimaric acid and the chlorinated resin acids, all of the resin acids have been measured at levels exceeding their reported 96-h LC50 values, indicating their presence in the effluent at acutely lethal levels. Total organochlorines, as measured by AOX, averaged 4.8 kg/ADt in the pre-modernized mill, which is close to twice the

Ministry of Environment, Lands and Parks mandated level of 2.5 kg/ADt (for 1991). The organochlorines identified from the effluent included 2,3,7,8-TCDF, H_6CDD, all five chlorophenol congeners (mono- to penta-), the chloroguaiacols, and chlorocatechols. With mill modernization proceeding, Celgar is expected to meet the 1.5 kg/ADt objective by July 1, 1994.

The City of Castlegar

The City of Castlegar has two separate secondary sewage treatment systems: one on the north bank of the river authorized to discharge 45% of the City's effluent and one on the east side of the river authorized to discharge the remainder. All available effluent data have been within the permitted maximum levels. The minimum dilution available for the total effluent in the Columbia River is in excess of 5500:1.

WATER QUALITY

Assessment of the available data indicates that effluent from the Celgar pulp mill has been negatively altering the water quality of the Columbia River, although the large river dilution, periodic flushing, and dissolved gas supersaturation from the Keenleyside Dam ameliorate much of the toxicity impact.

The colour of the Columbia River between the mill and the Kootenay River was degraded by the effluent to dark brown and could reach levels which impaired the water for downstream recreational use and for drinking water. Surface foaming and taste and odour problems due to the pulp mill effluent are also recurring aesthetic problems with the mill in its present state. Mill modernization is projected to reduce (although not eliminate) the discolouration and eliminate the foaming and taste and odour problems.

Acute toxicity was not a problem in the Columbia River downstream from Celgar's discharge outside the initial dilution zone; however, sublethal stress on aquatic organisms was expected to occur between Celgar and the Kootenay River confluence under present pre-modernized conditions. With mill modernization and secondary treatment, there should be few sublethal effects beyond the initial dilution zone. Receiving water resin acid levels were within the B.C. working criteria for the protection of aquatic life and by themselves were not responsible for sublethality outside the initial dilution zone. Organochlorines (as

measured by AOX) have contaminated the water column of the river downstream from the mill to at least the U.S. border. All receiving water chlorophenol measurements, however, have been less than the interim B.C. criteria for the protection of aquatic life. The only dioxin/furan congener detected in the receiving waters has been H_7CDD at 0.12 pg TCDD TEQ/L, which is considerably lower than the interim guideline for dioxins in drinking water (15 pg/L). The sediments downstream from Celgar have also been found to be contaminated with organochlorines, including EOX, dioxins (H_6CDD, H_7CDD, OCDD), furans (TCDF, PCDF), and chlorinated phenolics (guaiacols, catechols, anisoles, and veratroles).

Fibre discharge from the mill has resulted in fibre-matting on the bottom of the Columbia River for up to 2 km downstream from Celgar. The fibre mat is comprised of decomposed pulp fibres, fine sediments, and a slime covering or biofilm. Chemical analysis of this material indicated that organochlorines are present, but not at levels which would classify the material as "special waste" under the proposed M.O.E. Special Waste Regulations.

High levels of dissolved gases were present downstream from the Keenleyside Dam as far as the Roosevelt Reservoir. Approximately 80% of dissolved gas measurements have exceeded 110%, which is the approximate threshold for acute effects. It is not presently known to what extent gas supersaturation affects the health of aquatic life in the Columbia River. Severe gas bubble disease observations have not been made to date, nor have there been significant fish kills reported. Installation of turbines in the Keenleyside Dam, as proposed by B.C. Hydro, would ameliorate dissolved gas supersaturation for most of the year when the sluiceway is not used.

Celgar's effluent has had minimal effect on the suspended solids, pH, or dissolved oxygen of the receiving waters. Water column pH has continued to remain in the pH 6.5 - 8.5 range, thereby meeting the approved B.C. criteria for pH. There is also no evidence from monitoring data that effluent induced suspended solids have exceeded 10 mg/L over background, B.C.'s approved criteria for the protection of aquatic life. All surface dissolved oxygen data for this reach have been high, exceeding 10 mg/L. The supersaturated conditions created by the Keenleyside Dam allow for ready assimilation of the high BOD loadings from the pulp mill. Even with a future scenario of reduced dissolved gas supersaturation (due to turbine installation at Keenleyside Dam), dissolved

oxygen levels are not projected to fall below a minimum of 9.5 mg/L (largely because of mill modernization and BOD reductions).

The Celgar mill accounted for approximately 90% of the total phosphorus and 92% of the total nitrogen entering this reach of the Columbia River; however, these loadings have not contributed to eutrophication or excess algal growth. Predicted receiving water nutrient concentrations for post-expansion have been calculated and indicate no change over present total phosphorus increases, but a three-fold increase in Kjeldahl nitrogen concentration. This indicates that mill expansion could further increase the phosphorus limitation on downstream algal growth.

Benthic Macroinvertebrates

The available information shows that some toxicity effects have occurred among the more sensitive benthic macroinvertebrate populations of the Columbia River within this reach. Sensitive organisms are no longer a significant component of the benthic community. There has been an accomodation of community structure with invertebrates classed as tolerant and facultative (considered less desirable from a fish-food perspective) dominating from Celgar to the Kootenay River.

Analysis of freshwater mussel tissue has indicated the presence of chlorophenol, chloroguaiacol, and dioxin/furan contamination in animals sampled downstream from Celgar. Low levels of TCDD and TCDF were present in mussels taken upstream from Celgar. The implications of these mussel tissue organochlorine levels for the health of the mussel community is presently unknown. These levels, however, may be sufficiently high to be unsafe for wildlife and human consumers.

Fish Tissue Dioxin and Furan Residues

The furan 2,3,7,8-TCDF has been the predominant congener contaminating the fish of the Columbia River, with the highest levels found in whitefish and sturgeon. In a North American context, the TCDF levels downstream from Celgar were high and would rank among the most contaminated samples measured to date. Dioxins also contaminate the lake whitefish (2,4,7,8-TCDD) and rainbow trout (OCDD,H_6CDD, H_7CDD) in this reach. All of the fish species tested downstream from Celgar had tissue TCDD TEQ levels exceeding the threshold for EROD (an hepatic mixed function oxidase enzyme) induction, an early

warning stress threshold. TCDD concentrations in whitefish eggs from Roosevelt Reservoir have also exceeded the TCDD concentration in lake trout eggs reported to cause 50 percent mortality (LD50) in swim-up fry. This suggests the possibility of reproduction impairment in the fish community downstream from Celgar. The majority of samples also exceeded a reported tissue criterion for the protection of wildlife feeding primarily on fish.

WATER QUALITY OBJECTIVES

Provisional water quality objectives are set to protect a variety of designated water uses between the Keenleyside Dam and Birchbank including: aquatic life (and their habitats), wildlife consumption of aquatic life, recreational use, aesthetic values, and drinking water. As future receiving water monitoring programs improve the data base and as changes in effluent quality occur (e.g., pulp mill modernization), these objectives will be reviewed and revised if necessary. The provisional objectives are shown in Tables 1 and 2.

These objectives apply to all parts of this reach of the Columbia River, except for the initial dilution zones of effluents. This is the initial part of the mixing zone where the Province accepts some degree of adverse biological effect , i.e., sublethal stress, but not conditions that are acutely toxic or that would cause harmful bioaccumulation, or adverse sludge deposits. For this reach of the Columbia River these excluded dilution zones are defined arbitrarily as extending up to 100 m downstream from the discharge point from the surface to the bottom and no more than 50 % across the width of the river for the pulp mill discharge and no more than 25 % for all other discharges. Initial dilution zones are not to impinge on bathing beaches or fish spawning habitat.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. They will guide the evaluation of water quality, the issuing of permits, licenses, and orders, and the management of the fisheries and of the Province's land base. They will also provide a reference against which the state of water quality in a particular water body can be checked, and serve to make decisions on whether to initiate basin-wide water quality studies.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be met in the future. To

limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by man's activity, now and in the foreseeable future.

The provisional objectives for dissolved oxygen, pH, temperature, resin acids, and suspended solids and turbidity are presently being met all of the time and can also be met in the future. The provisional objectives for colour, substrate sedimentation, and dissolved gases are not being met at present and are not projected to be met in the near future right at the edge of the initial dilution zone for the Celgar mill (although the dissolved gases objective can be met with future changes to the Keenleyside Dam). Those characteristics which are exceeding the recommended objectives at present, but which could meet them in the near future with pulp mill modernization and secondary treatment, include toxicity and chlorinated resin acids. The objectives for dioxins and furans in fish tissue and sediment, presently exceeding the objectives, may take a longer time for attainment as levels in the sediments and food-chain are dissipated. At this time there are insufficient data to determine whether the objectives for microbiological indicators, periphyton standing crop, chlorophenols, or chlorinated dioxins and furans (in water) are being met at or could be met in the future.

MONITORING

The recommended receiving water quality monitoring program is outlined in Table 3. This is a minimum monitoring program and was designed to check attainment of the objectives set for the Keenleyside to Birchbank reach of the Columbia River. It is part of the larger Lower Columbia River Integrated Environmental Monitoring Program (CRIEMP) which started in 1991 with the cooperation of the B.C. Ministry of Environment, Environment Canada, Department of Fisheries and Oceans, the City of Castlegar, the City of Trail, and the industrial users (Cominco, B.C. Hydro, and Celgar). CRIEMP has begun monthly monitoring for most characteristics and these additional data will be used in any assessment of whether or not the water quality objectives are being met. The results will be published by the Water Quality Branch in its annual report on the attainment of all provincial water quality objectives.

G. A. Butcher
Water Quality Branch
Water Management Division

TABLE 1

Provisional Water Quality Objectives for the Lower Columbia River (Keenleyside Dam to Birchbank)

DESIGNATED WATER USES → CHARACTERISTICS ↓	Aquatic Life, wildlife, recreation, and drinking water
Dissolved Oxygen	10 mg/L (minimum)
pH	unrestricted change in pH 6.5-8.5 (CO_2<60mg/L)
Colour	15 TCU (maximum)
Suspended Solids[1]	10 mg/L (maximum increase)
Turbidity[1]	5 NTU (maximum increase)
Substrate Sedimentation[6,4]	Sediment TOC - no increase between upstream and downstream levels at 95% confidence level
Temperature	<1°C (maximum increase)
Dissolved Gases	<110% (maximum saturation)
Fecal Coliforms [2]	<100/100 mL (90^{th} percentile)
Escherichia coli [2]	<100/100 mL (90^{th} percentile)
Toxicity	% conc. of mill effluent in water <0.05 of the 96-h LC50, after complete mixing
Chlorinated Phenols	T_3CP < 0.05 ug/L T_4Cp < 0.1 ug/L PCP < 0.05 ug/L
Dioxins/Furans in Fish [3]	1 pg TCDD TEQ/g (ppt) (maximum)
Dioxins/Furans in Water	0.2 pg TCDD TEQ/L (ppq) (maximum)
Dioxins/Furans in Sediment [4]	0.7 pgTCDD TEQ/g of sediment TOC (maximum)
Resin Acids in Water	as shown in Table 2
Chlorinated Resin Acids in Water	6.0 ug/L (maximum) for each of monochloro-DHA and dichloro-DHA
Periphyton Standing Crop[5]	<50 mg/m^2 chlorophyll a (average)

Note: the objectives apply to discrete samples from all parts of the waterbody, except from initial dilution zones of effluents. This exclusion does not apply to objectives for fish as noted in 3 below.

1. The increase (in mg/L or NTU) is over levels measured at a control site away from a discharge or series of discharges and as close to them as possible and applies to areas affected by the discharge.

2. The 90^{th} percentile is calculated from at least 5 weekly samples taken in a period of 30 days.

3. The objective applies only to muscle tissue (not to the whole fish or organs) of a fish of any species caught in any part of the waterbody, including initial dilution zones of effluents. It is expressed on a wet weight basis.

4. The sediment level is the average of the results from at least 3 replicate samples of bottom surface sediments at each site on any one sampling date.

5. The average is calculated from at least six randomly located samples from natural substrates at each site on any one sampling date.

6. The increase applies to the total organic carbon content of surface bottom sediments. No increase means that there should be no significant difference in sediment TOC, at the 95% confidence level, between an upstream control site and an affected site outside the initial dilution zones of effluents.

TABLE 2

RESIN ACIDS OBJECTIVES

- the total concentrations of dehydroabietic acid (DHA) and total resin acids in water should not exceed the following concentrations for the given range of receiving water pH values:

Receiving Water pH	DHA ug/L	Total Resin Acids* ug/L
6.5	4	9
7.0	8	25
7.5	12	45
8.0	13	52
8.5	14	60

* total resin acids are defined as the sum of the individual concentrations of abietic, dehydroabietic, isopimaric, levopimaric, neoabietic, pimaric, and sandaracopimaric acids.

TABLE 3
RECOMMENDED RECEIVING WATER MONITORING
KEENLEYSIDE DAM TO BIRCHBANK

SITE LOCATION	SITE NUMBER	SAMPLING FREQUENCY	DATE	No.	CHARACTERISTICS
Upstream from Celgar 100m d/sCelgar At Castlegar	0200183 New Site 0200200	5 weekly samples in 30 days	April	15	Temperature, D.O., pH, suspended solids, turbidity, colour, sodium, total dissolved gases, fecal coliforms, E. coli, Enterococci, foam/floatables/odo observations
		Once	April	3	Resin acids, chlorinated resin acids, chloroguaiacols & chlorophenols, AOX dioxins/furans (latter in sedimen and water)
Birchbank	0200003	5 weekly samples in 30 days	April	5	D.O., total dissolved gases, E. coli, Enterococci, foam/floatables/odor observatio
		Twice between Fed.-Prov. biweekly sampling	March-April	2	Temperature, pH, suspended solids, turbidity, colour, sodiu fecal coliforms
Birchbank	0200003	Once	April	1	Resin acids, chlorinated resin acids, chloroguaiacols & chlorophenols, dioxins/furans (latter in water and sediment)
u/s and d/s of Celgar and at Birchbank	0200183 0200200 0200003	Once	Summer	3	Periphyton Standing Crop
Upstream and Downstream of Celgar	2 New Sites	Once	Not Specific	3 3	substrate sedimentation (TOC)
Between Celgar and Kootenay R.	-	Once annual	Not Specific	4 4	Fish tissue dioxin/furan levels[1] Sediment dioxin/furan levels[2]

This is a minimum monitoring program designed to measure the attainment of the recommended water quality objectives. This program is augmented by the data being generated under the auspices of the Columbia River Integrated Monitoring Program (CRIEMP).

1 - sport fish fillet (species to be determined by Regional sampler). To include minimum of one reference site

2 - to include a minimum of one reference site

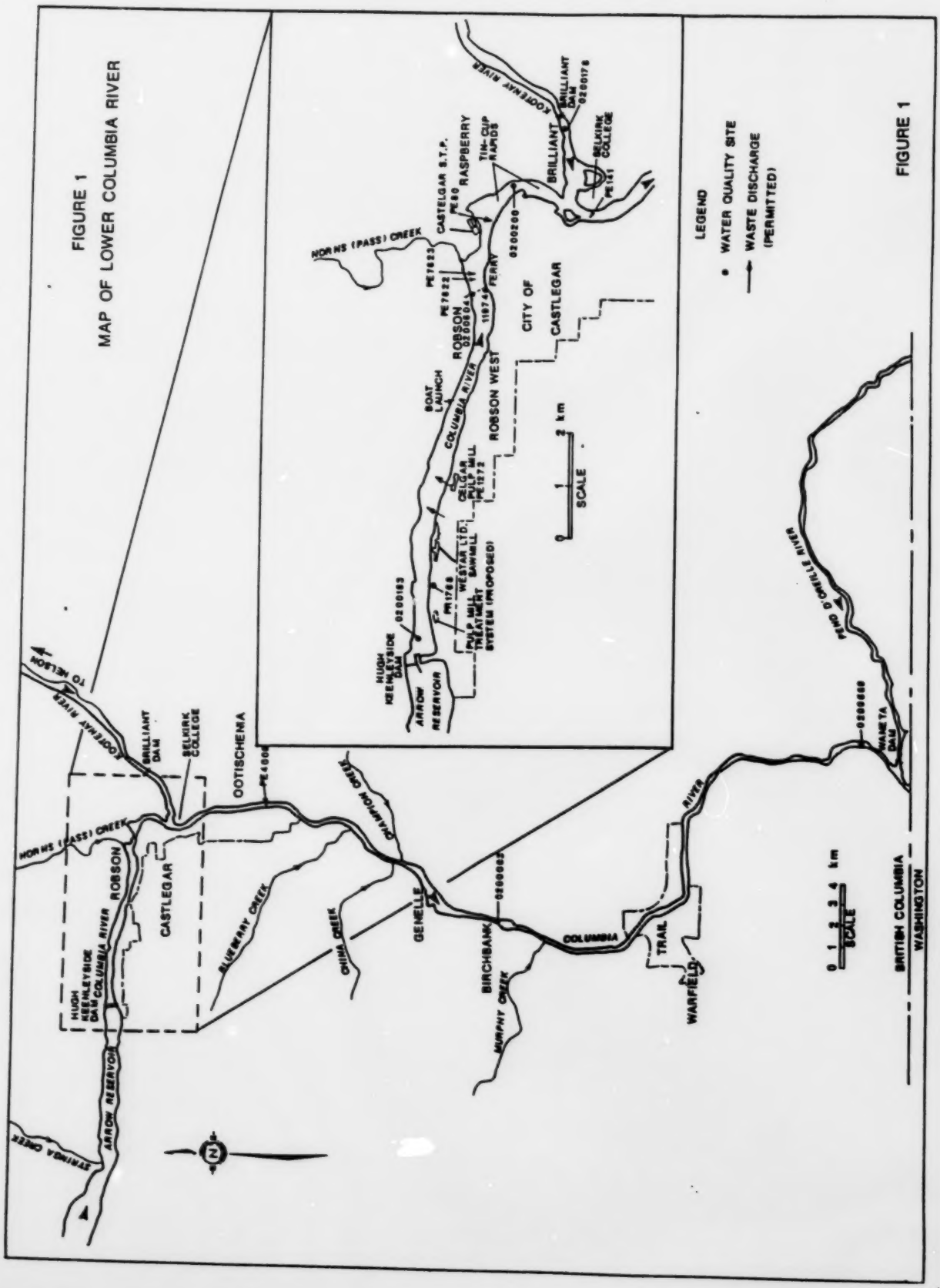
FIGURE 1
MAP OF LOWER COLUMBIA RIVER
TO NELSON
KOOTENAY RIVER
BRILLIANT DAM
BELKIRK COLLEGE
OOTISCHENA
HORNS (PASS) CREEK
ROBSON
CASTLEGAR
HUGH KEENLEYSIDE DAM
COLUMBIA RIVER
ARROW RESERVOIR
TARRIER CREEK
BLUEBERRY CREEK
OHIO CREEK
GENELLE
BIRCHBANK
MURPHY CREEK
COLUMBIA
TRAIL
WARFIELD
PEND D'OREILLE RIVER
WANETA DAM
BRITISH COLUMBIA
WASHINGTON
SCALE
0 1 2 3 4 km
CASTELGAR S.T.P.
RASPBERRY
TIN-CUP RAPIDS
BRILLIANT
BRILLIANT DAM
BELKIRK COLLEGE
ROBSON
PERRY
CITY OF
CASTLEGAR
ROBSON WEST
BOAT LAUNCH
WESTAR (T.D.) SAWMILL
CELGAR PULP MILL
PULP MILL EFFLUENT SYSTEM (PROPOSED)
HUGH KEENLEYSIDE DAM
ARROW RESERVOIR
0 1 2 km
SCALE
LEGEND
WATER QUALITY SITE
WASTE DISCHARGE (PERMITTED)
FIGURE 1